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DIURNAL FLYING ACTIVITY AND NUTRITION ECOLOGY OF HYDROTAEA ARMIPES FALL. (DIPTERA, MUSCIDAE)

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Abstract. The activity of the fly *Hydrotaea armipes* Fall. alighting on the lachrymous eyes of calves was observed. The flies were active throughout the day at the temperature higher than 12 °C, their activity inside the stable being about directly proportional to their activity in the paddocks. The numbers of active females indoors reached 0.08—17.3% of the number of active females in the paddocks. The flight range of females from paddocks or buildings for the housing of calves was no more than 10—20 m. The authors presume that the alighting *H. armipes* females orientate themselves to a greater distance (more than 5 m) visually, while in the approaching phase of their flight chemotactic orientation predominates in them.

In connection with the epizootic incidence of infectious bovine keratoconjunctivitis (IBK) in western Bohemia a survey of the fauna of synbovine Diptera as potential vectors of this disease was conducted there between 1976 and 1979. While investigating several large-scale calf units in the district of Stříbro recorded was a relatively high occurrence of the fly *Hydrotaea armipes* Fall. which alighted on the lachrymous eyes of calves both in the paddocks and in the calf houses and fed on the eye secrets and tears of healthy as well as sick animals (Fig. 1). Because this finding was quite new, attention was focused on this species, and its bionomy, diurnal flight activity, nutrition ecology and dispersal of imagoes was studied. The simultaneously studied role of *H. armipes* in the transmission of IBK agent from the sick to the healthy calves is reported in a separate paper (Dusbábek et al. 1982).

The diet of *H. armipes* imagoes is relatively wide in scope. A number of authors recorded imagoes alighting on cattle or appearing in traps with different bait (excrements, rotten meat etc.). As attractive baits Kühlhorn (1979) indicated excrements, cadavers, food and fodder. Makhanko (1973) studied the morphology of oral hooks in the genus *Hydrotaea* depending on the facultative blood taking from warm-blooded animals and listed *H. armipes* in the group of haematophags capable only of licking the freely flowing blood and unable to inflict bleeding lesions in the skin (see also Berlyn 1978b). The only paper concerning the nutrition ecology of *H. armipes* imagoes was written by Garcia and Radovsky (1962), who studied facultative haematophagia of the species *H. armipes* and *Fannia benjamini* Malloch. The only existing data on the anthophilia of *H. armipes* imagoes is to be found in the paper of Ringdahl (1950 — see Hennig 1955). As far as is known to us there has been no published data about the active alighting of *H. armipes* on the eyes of domestic animals.

MATERIAL AND METHODS

The flight activity of *H. armipes* was observed according to the intensity at which the flies were alighting on the lachrymous eyes of a particular calf (aged 4—6 months) in the paddock close to the calf house (Fig. 2). All flies alighting on the site in the immediate vicinity of the eye and the hair wetted by tears were being caught with hand-held sweep net for twenty minutes at each full hour. After terminating the 20-minute period the captured flies were placed in cages, identified, counted and released. At the start of each collecting the basic meteorological data (temperature

and relative air humidity, presence of clouds and light intensity, precipitation and wind velocity) were determined by current methods. Simultaneously the flies were being caught by a similar method in the stables. Between June 1977 and September 1978 a total of 10 round-the-clock catches were carried out. The appearance of *Musca autumnalis* De Geer imagoes and *H. armipes* males were recorded in some catches only.

In order to obtain orientation data on the scope of the imagoes'diet, their dispersal, migration and resting sites, the following methods were used: collecting into silhouette traps (of the Skufin and canopy type), net trailing over vegetation, collecting on the windows of the stables, collecting in classical traps with different baits and directly on the calves.

Locality. The Těchlovice large-scale calf unit is situated on an upland plain at the altitude of 430 m in the vicinity of the village, surrounded by field crops; in the radius of 1 km there are no pastures, meadows and forests. The space between the buildings are mostly grassy with sporadic shrubs and trees in the fence. The possibility that typical pasture and forest species of flies attacking cattle would migrate and survive in the area of the farm, is quite small.

Fig. 1. Females of *Hydrotaea armipes* Fall. feeding on tears in the eye region of the calf.

RESULTS

1. Diurnal activity: The flight activity of *Hydrotaea armipes* and *Musca autumnalis* in relation to meteorological conditions is shown in Figs. 3—5. Under balanced meteorological conditions (Fig. 3, Graphs 1 and 2) and at the temperature above 12° C the attacks were low and without peaks. The intensity of the attacks appeared to fluctuate in correspondence with temperature, but the two decreases on Graph 1 were apparently caused by a shower. On a half-clear, windy day with temperature above 12 °C (Fig. 4, Graph 3) a low intensity of attacks was recorded throughout the day, with an increased activity of the flies at late afternoon and evening hours. Fig. 3, Graph 4, depicts a gradual increase of activity as late as 7.00 hours and the appearance of 8 *H. armipes* females at 5.00 hours was evidently provoked by the movement of an animal being brought in. The inexpressive peak at noon was twice interrupted by a light rain. Fig. 4, Graph 5, depicts the

situation on the first day of weather improvement after a 10-day cold and rainy spell. The flies were stimulated to activity by the rise of temperature above 12 °C at 9.30 hours. The remaining part of the day was marked by constant and very numerous attacks. During the observations shown in Fig. 4, Graph 6, the activity started only at 15 °C, at the moment when the mist dissolved at 10.00 hours. Exceptionally numerous attacks reached their peak at 18.00 hours and ended at full dusk. Fig. 4, Graph 7, depicts the situation during the anticyclon clear weather with a shorter part of the daylight and a lower air temperature. The one-peak curve of the fly activity was limited to

Fig. 2. The standard collecting of flies from the eyes of the experimental calf fixed to the paddock fence. Left: canopy trap.

a 7-hour section with the temperature higher than 12 °C. During the typically anticyclon weather with the maximum temperature of 28 °C, a long part of the daylight and low relative air humidity (as low as 33 %) (Fig. 4, Graph 8) the activity of *H. armipes* was marked by a distinct two-peak curve with the morning peak at 9.00 hours and a noon lull. This decrease might have been influenced by the competition with *M. autumnalis*, whose activity increased at noon hours.

Our observations showed that the *H. armipes* females were alighting on the experimental calves throughout the day, from the daybreak to the evening dusk at the temperature higher than 12 °C. This lower limit of temperature was strictly adhered to. At the temperature above 25 °C the activity was decreasing, probably due to the influence of the proportionally decreased relative air humidity under 50 %. The changes of the air humidity ranging from about 50 to 90 % were not in relation with the fluctuation of the *H. armipes* activity. From the graphs no dependence between the sunshine changes and the *H. armipes* activity could be read, the latter not having been ascertained

even by direct observation during a distinctly changing cloudiness. The flight activity of the *H. armipes* imagoes was affected by precipitation — reduced by a light rain and stopped by a heavy shower, a morning mist making the imagoes inactive. The wind velocity above 7 m/sec slowed down the flight activity of the flies.

Even under optimal abiotic conditions apparently only one portion of the *H. armipes* population was active. The activity before evening was frequently intensified by a more

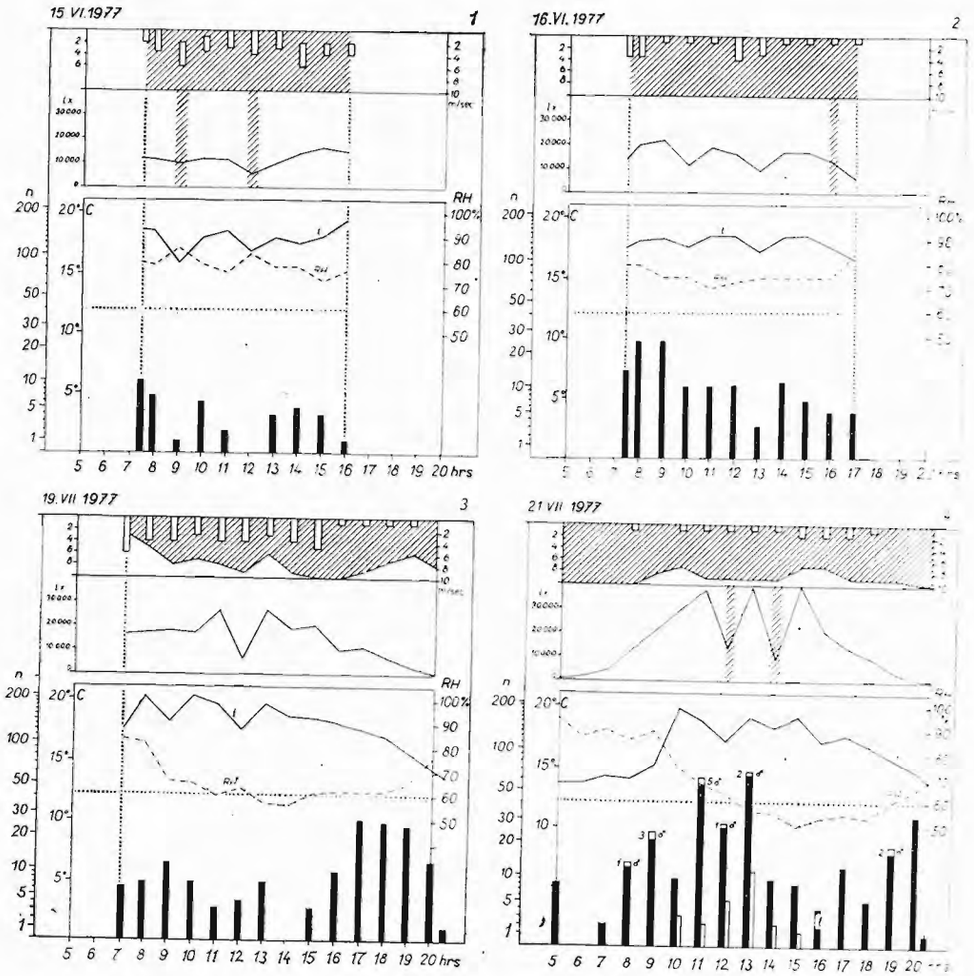

Fig. 3. The flight activity of *Hydrotaea armipes* Fall. and *Musca autumnalis* De Geer in the paddock adjoining the stable in relation to meteorological conditions. Graph 1 — 15. 6. 1977; Graph 2 — 16. 6. 1977; Graph 3 — 19. 9. 1977; Graph 4 — 21. 7. 1977.
Explanations: Numbers of *Hydrotaea armipes* (black columns) and *Musca autumnalis* (white columns) collected in the standard collecting (in 20 minutes each hour) in the eye region of the exposed calf, expressed on logarithmic scale (in); curve of temperature (°C — solid line) and relative air humidity (% RH — broken line); curve of light intensity fluctuation in luxes with rain (crosshatching) or mist (stippling); cloudiness in tenths of sky coverage (crosshatching) and scope of wind velocity (m/sec) during collecting (oblongs) with similar scale interval.

aggressive attacks of *H. armipes* females on the eyes of the animals and by the appearance of single males trying to copulate with the females feeding in the vicinity of eyes.

Graph 4 (Fig. 3) and Graphs 5, 6 and 8 (Fig. 4) indicate a mild competition between the alighting imagoes of *H. armipes* and *M. autumnalis*, which would fly to the paddocks on sunny days. In all four cases the appearance of *M. autumnalis* was followed by a decrease in the number of *H. armipes*. One of the causes of this phenomenon were the higher heat requirements and heliophilia of *M. autumnalis*. The next cause was the fact confirmed by our direct observations, that the much stouter and more aggressive imagoes of *M. autumnalis* displaced the smaller specimens of *H. armipes* from the eye region.

During the day the flight activity of *H. armipes* females inside the stable reflected the increased activity outside, both values being approximately directly proportionate (Fig. 5). The lowest intensity of light at which the females of *H. armipes* were active in the stable amounted to 89 luxes near the entrance and 19 luxes in the centre of the stable. So far as the *H. armipes* females were not active in the paddock in unfavourable weather conditions (e.g. observations of 5 July, 1978), they were not found inside the stable either. The proportion of *H. armipes* females active indoors to the number of females active in the paddock distinctly varied between a maximum of 17.3 % or 7.5 % (the former value at the entrance, the latter in the centre of the stable) and a minimum of 0.4 % or 0.08 %. A relatively higher number of females penetrated into the stable in the less favourable spring and autumn periods, a relatively lowest number in the high summer.

2. Dispersal and migration. The dispersal of *H. armipes* imagoes in the surroundings of the buildings was ascertained by net trailing over vegetation each month of the flight season (a total of 2000 sweeps with the entomological net) at certain distances from the paddock fence. The resulting mean number of specimens per 100 sweeps was as follows: on the shrubs *Sambucus nigra* growing through the paddock fence (Fig. 2) — 13.1 ♀ and 3.9 ♂; in the grass cover about 5 m distant from the fence — 2.4♀ and 0.4 ♂; on the shrubs about 50—80 m distant from the paddocks — 0.8 ♀; in the grass cover 50 m away from the paddocks no *H. armipes* imagoes were found.

During the normal rearing regime of calves, when the animals were let out into the adjoining paddocks, the *H. armipes* females migrated from the vegetation to the animals and back. Some number of active females was seen penetrating into the stables through the open windows, paddock gates and main gates and returning again. During this second migration flight some imagoes got caught in the closed stable windows. The highest number of females per 1 m² of window area ascertained in one case only, amounted to 4 specimens.

The results of these tests supplemented with direct observations can be summed up as follows: the *H. armipes* females were always to be found near the animals, from which they did not move actively over a distance greater than about 10—20 m. In this relatively narrow zone around the buildings and paddocks the *H. armipes* imagoes distinctly preferred shrubs and trees as their resting sites, where they took shelter almost exclusively on the back side of leaves. Off the vegetation, e.g. on the walls and fences or inside the stables the resting imagoes were never observed. It can be therefore stated that the phase of food-searching activity practically alternated with only the resting phase on the vegetation and with the period necessary for copulation and oviposition.

3. Nutrition ecology. In this section we are summing up our preliminary observations aiming at the elucidation of the diet preferred by *H. armipes* imagoes and of their orientation during the attacks on the eyes of calves reared in large capacity buildings.

In the period between 7 June and 21 July 1977 a trap baited with fresh faeces of calves was set up 14 times in the grass cover about 1—4 m distant from the paddocks.

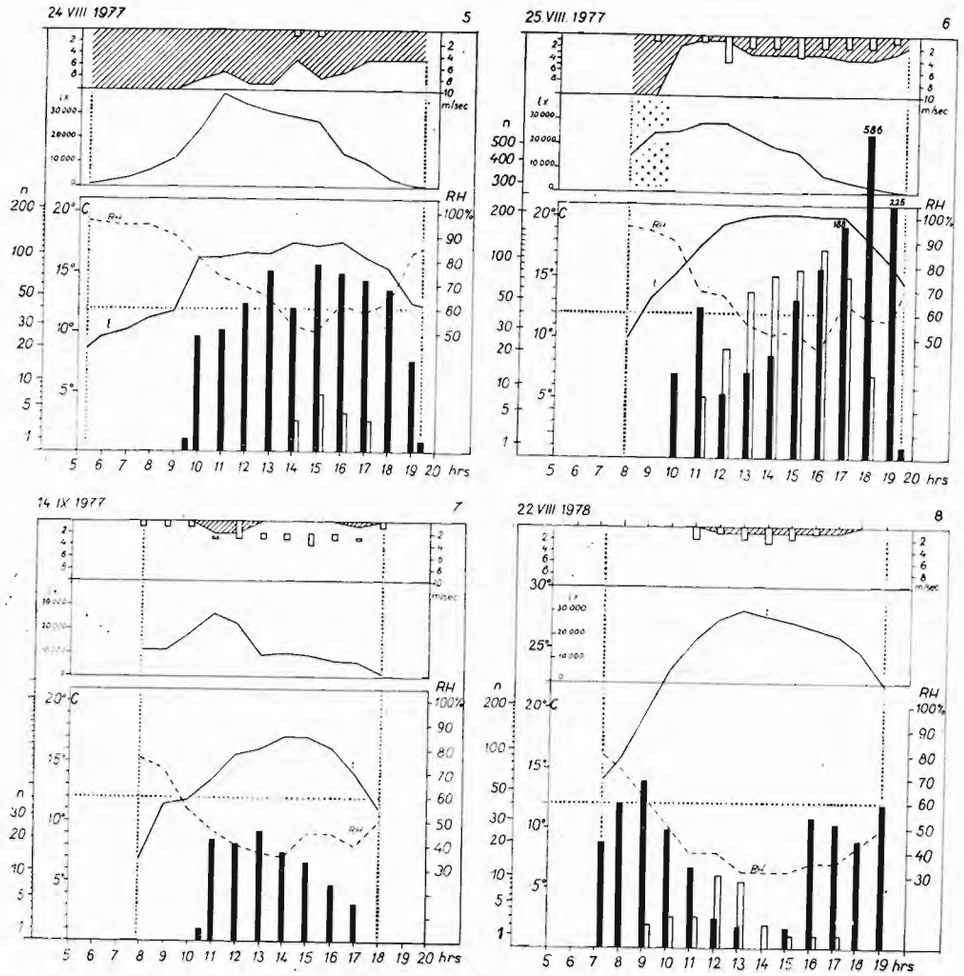

Fig. 4. The flight activity of *Hydrotaea armipes* Fall. and *Musca autumnalis* De Geer in the paddock adjoining the stables in relation to meteorological conditions (continued). Graph 5 — 24. 8. 1977; Graph 6 — 25. 8. 1977; Graph 7 — 14. 9. 1977; Graph 8 — 22. 8. 1978

Only five catches were positive on the presence of *H. armipes* amounting to a total of 8 ♀ (Table 1), representing a negligible part of the local fly population. The bait used was mostly attractive enough for the characteristic coprophagous flies, except for *Musca autumnalis*, whose females searched for fresh bovine excrements in the pastures. Likewise used were human faeces (4 cases), but yielded 2 ♀ *H. armipes* in one case only. Bad meat (liver), cheese, bovine tears and blood (each 5 ccm in Petri dishes) used both in the traps and freely exposed in the paddocks proved to be quite unattractive for *H. armipes*. These negative results prompted us to apply fresh blood and tears directly to the hair of the experimental calf. Circular spots of the hair on the sides of the calf, 10 cm in diameter each were wetted with them and every minute the number of *H. armipes* occurring on these spots, on the control area wetted with water, as well as the

Table 1. A survey of characteristic species of synbovine flies collected in a trap baited with fresh calf faeces in the immediate vicinity of paddock adjoining the stable (catches from 7 June to 21 July 1977 in periods of 1—8 hours)

Reference No. of catch:	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Hydrotaea armipes Fall.	1	.	.	1	1	.	.	4	1	.	.	.	.	.
Musca autumnalis De Geer	.	.	.	.	.	.	2	.	.	.	.	.	.	.
Musca domestica L.	4	.	.	.	.	.	.	.	.	.	.	.	.	.
Morellia hortorum (Fall.)	6	11	3	.	.	.	4	.	.	.	.	.	.	.
Orthellia caesarion (Meigen)	.	.	3	.	1	.	5	.	.	1	8	.	.	.
Myopsila meditabunda (Fabr.)	.	.	20	1	1	.	16	.	1	3	3	1	1	.
Paregle cinerella (Fall.)	.	.	19	.	20	23	110	.	7	6	12	9	2	11

Table 2. Numbers of *Hydrotaea armipes* imagoes alighting on natural attractants applied to the hair of the experimental calf

Attractant	eye	blood	tears	water
Experiment A 16. 6. 1977 8.35—9.35 hours	63 ♀	(not used)	102 ♀, 1 ♂	10 ♀
Experiment B 16. 6. 1977 11.53—11.57	83 ♀	190 ♀	67 ♀	3 ♀

Table 3. A survey of most important haematophagous and secretophagous fly species collected in a canopy trap near a paddock adjoining the stable (column 1, 14.6.1977) and beyond the paddock fence (columns 2—5, 22. 8. 1978). Meteorological conditions for columns 2—5 and activity of *H. armipes* and *M. autumnalis* alighting on the calf's eyes are depicted on Graph 8 (Fig. 4)

Hour	9–17	8.30–10	10.30–13	14–16.30	16.30–8
Reference No of catch	1	2	3	4	5
Hydrotaea armipes Fall.	2	19	.	11	16
H. meteorica L.	.	5	7	7	5
H. albipuncta Ztt.	.	3	1	1	2
H. irritans (Fall.)	1	1	2	.	1
Musca autumnalis De Geer	.	3	11	16	5
Morellia hortorum Fall.	.	.	2	3	4
Stomoxys calcitrans (L.)	.	.	6	3	1

number of specimens occurring in the eye region of the same side of the animal, were registered. The sums total of particular observations taken at minutes' intervals are given in Table 2. With absence of blood in test A the tears in the hair proved to be more attractive than the lachrymous eye, the blood in test B proved to be the most attractive to the flies.

Another observation was resolving the problem of potential visual orientation of

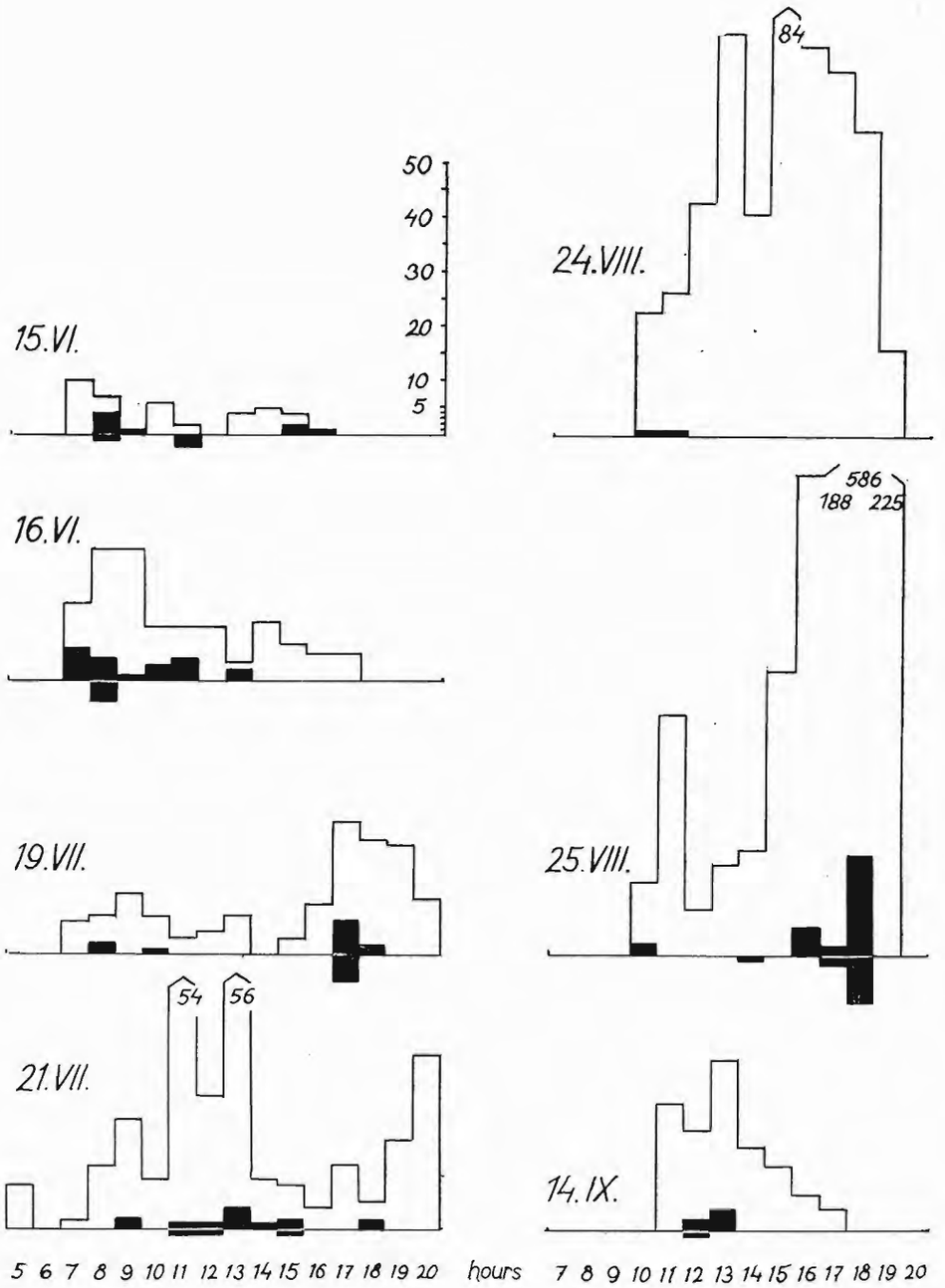

Fig. 5. A comparison between the attacks of *Hydrotaea armipes* Fall. females on the eyes of calves in the paddock (white columns) and inside the stable (black columns). Above the horizontal axis — collecting at the entrance, below the axis — in the centre of the calf house

H. armipes females searching for food. Our experiments with simulated eyes placed on the head and body of the calf were quite negative. On the other hand, the appearance of imagoes of both sexes in the traps of the Manitoba and Skufin types was already reported (Gregor and Minář 1980). In the area of the Těchlovice large-scale calf unit a trap of the canopy type was used with positive results (Table 3, Fig. 2). The weather conditions on 14 June 1977 were similar to those on 15 June 1977 (see Fig. 3 Graph 1,) and this fact explains the generally low number of Diptera which made their appearance on that day. In the August experiment the changes in the numbers of alighting flies *H. armipes* and *M. autumnalis* throughout the day very well corresponded with the course of diurnal activity ascertained by observing their attacks on the experimental calf (Fig. 4, Graph 8).

In order to confirm the data of Ringdahl (1950 — see Hennig 1955) who observed *H. armipes* imagoes on the flowers of *Solidago virgaurea*, we regularly swept the flowers of *Sambucus nigra* growing in the paddock fence (Fig. 2), but the result was negative.

DISCUSSION AND CONCLUSIONS

On the basis of synecological studies Gregor and Minář (1980) listed the species *H. armipes* in the group of secretophagous synbovine flies, i.e. those which obligatorily feed on the body secrets or non-parasitically on the blood of warm-blooded animals. On the basis of data presented in this paper we designate *H. armipes* (in the sense of the classification of Gregor and Povolný 1958) as an eusynbovine, secretophagous and exophilic species, with accidental endophilia.

In the conditions of large-scale animal production units studied the paddocks adjoining the stables were inhabited by a single secretophagous species of the genus *Hydrotaea*. The other species belonging to this genus, *H. meteorica* L., *H. albipuncta* Ztt. and *H. irritans* (Fall.) were detected on the eyes of experimental calves only in 0.6% of the specimens captured. In this ecological niche only *Musca autumnalis*, which in essentially a pasture species, was associated with *H. armipes*.

The results obtained in our observations on the diurnal flight and feeding activities of *H. armipes* females agree to a considerable degree with the results obtained by Nielsen et al. (1971, 1972) and Berlyn (1978b) in their studies on the flight activity of the species *Hydrotaea irritans* in the seaside pastures in Denmark and western Scotland. Agreeing are primarily the lower limit of the flight activity at 12 °C, the flight activity even at a very low light intensity and the reaction to weather. In contrast to *H. armipes* the species *H. irritans* is much more aggressive in its attacks on warm-blooded animals and its dispersal in the field is incomparably greater (Robinson and Luff 1979). The swarmings *H. irritans* with the presence of numerous males resemble the preconnubial societies. During the increased abundance of *H. armipes* 1—2 hours before the sunset we observed a stepped-up movement activity of females in the eye region of the calves, but the presence of males was sporadic only.

The hitherto known spectrum of substances attracting the females of *H. armipes* is relatively wide, but we cannot determine yet, which of these substances are the obligatory and indispensable component of food, which are the facultative one etc. As for the problem of orientation of females alighting on nutritive substrate, there is a certain discrepancy between the results of our observations and those obtained by Garcia and Radovsky (1962). These authors emphasize the visual orientation of *H. armipes* females in the approaching phase of the flight towards the source of food (the sucking horse flies or a dummy in experiment) and practically rule out the importance of scent. Our observations, however, suggest that at a greater distance (more than 5 m) the *H. armipes* females orientate themselves visually on large moving or only contrasting objects, similarly as most bloodsucking insects do (Skufin 1959, Bracken et al. 1962); in the approaching phase an important role is played by the scent zone in the immediate vicinity of the animal, the scent perception of the attracting secrets and probably the increased concentration of CO_2 as well, predominating. The chemotactic mode of orientation in the approaching phase corresponds with the higher catches of the *Hydrotaea irritans* in traps baited with CO_2 as attractant than in the classic Manitoba traps (Berlyn 1978a).

In conclusion we state that in *H. armipes* populations studied the lacrimal secrets of calves constituted the main food of females of this fly species. Heavy lacrimation observed in the high percentage of calves under given conditions apparently promoted a certain habitual preference to tears, which soon stimulated another requirement for tears due to their relatively low nutritional value. We did not observe any fundamental difference in the degree of attractiveness between the tears of healthy

eyes and the tears including bacterial microflora and pus from the eyes of infected animals. The facultative hematophagia, however, was apparently genetically dependent in *H. armipes* females which were more attracted to blood than tears, as evident in Table 2 and in the paper of Garcia and Radovsky (1962).

ДНЕВНАЯ АКТИВНОСТЬ ПОЛЕТА И ПИЩЕВАЯ ЭКОЛОГИЯ МУХИ *HYDROTAEA ARMIPES* FALL. (DIPTERA, MUSCIDAE)

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Резюме. Авторами изучалась активность мухи *Hydrotaea armipes* Fall. во время нападания на источающие слезы глаза телят. Мухи были активны в течение целого дня при температуре выше чем 12 °С, в то время как их активность внутри хлева была почти прямо пропорциональна активности на выгульных площадках. Численность активных самок внутри хлева достигала 0,08—17,3 % численности активных самок на выгульных площадках. Самки не вылетали от выгульных площадок или объектов для содержания телят более чем 10—20 м. Авторы предполагают, что нападающие самки *H. armipes* ориентируются на бóльшее расстояние (более чем 5 м) визуально, в посадочной фазе полёта у них преобладает химическо-тактическая ориентировка.

REFERENCES

BERLYN A. D., The flight activity of the sheep headfly, *Hydrotaea irritans* (Fallén) (Diptera: Muscidae). Bull. ent. Res. 68: 219—228, 1978a.

—, The field biology of the adult sheep headfly, *Hydrotaea irritans* (Fallén) (Diptera: Muscidae), in south-western Scotland. Bull. ent. Res. 68: 431—436, 1978b.

BRACKEN G. K., HANEC W., THORSTEINSON A. J., The orientation of horse flies and deer flies (Tabanidae: Diptera) II. The role of some visual factors in the attractiveness of decory silhouettes. Canad. J. Zool. 40: 685—695, 1962.

DUSBÁBEK F., SOUKUPOVÁ V., GREGOR F., KREJČÍ J., The role of *Hydrotaea armipes* Fall. (Diptera, Muscidae) in the transmission of infectious bovine keratoconjunctivitis. Folia parasit. (Praha) 29: 79—83, 1982.

GARCIA R., RADOVSKY F. J., Haematophagy by two non-biting muscid flies and its relationship to tabanid feeding. Can. Ent. 94: 1110 — 1116, 1962.

GREGOR F., MINÁŘ J., Collecting of synbovine Diptera in Skufin and Manitoba traps. Dipterologica Bohemoslovaca. Acta Univ. Carol. — Biologica, 287—295, 1980.

—, POVOLNÝ D., Versuch einer Klassifikation der synanthropen Fliegen. J. Hyg. Epid. Microbiol. Immunol. 2: 205—216, 1958.

HENNIG W., Muscidae. In: E. Lindner, Die Fliegen der paläarktischen Region 7 (63b), Stuttgart, 1110 pp., 1955—1964.

KÜHLHORN F., Dipterenfauna zoologischer Präparatorien und veterinärmedizinischen Sektionsräume. Angew. Parasitol. 20: 17—34, 1979.

MAKHANKO E. V., The degree of parasitism and the structure of mouth teeth in the species of synanthropic flies belonging to the genera *Hydrotaea* R. — D. and *Musca* L. (Diptera, Muscidae). Entomol. obozr. 52: 768—781, 1973. (In Russian.)

NIELSEN B. O., NIELSEN B. M., CHRISTENASEN O., Bidrag til plantagefluens, *Hydrotaea irritans* Fall., biologi (Diptera, Muscidae). Ent. Meddr. 39: 30—44, 1971.

—, —, —, Plantagefluen, *Hydrotaea irritans* (Fall.) pa graessende kvier (Diptera, Muscidae). Ent. Meddr. 40: 151—173, 1972.

ROBINSON J., LUFT M. L., Population estimates and dispersal of *Hydrotaea irritans* Fall. Ecol. Entomol. 4: 289—296, 1979.

SKUFIN K. B., To the knowledge of behaviour of horse flies (Tabanidae, Diptera) alighting on the prey. Sb. Ochrana prirody Centr. chernozem. polosy, Voronezh, vol. 2: 329 to 336, 1959. (In Russian.)

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